ASUU JOURNAL OF SCIENCE
A Journal of Research and Development
Vol 3, No. 2, December, 2016; pp. 79-88

Evaluation of Heavy Metals Composition in Selected Fruits Consumed in Kano Metropolis, Nigeria

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Abstract

Food chain pollution by heavy metals is increasingly becoming a burning issue in recent years due to their potential accumulation in biosystems. This study is aimed at evaluating the levels of heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb and Zn)in the pulps and peels of selected samples of fruit (Banana, Paw-paw, Orange, Guava and African mango) consumed in Kano metropolis. The levels of the heavy metals were analyzedusing Atomic Absorption Spectrophotometry. The results show that that Cd and Co levels in banana and paw-paw were above the permissible limits. Moreover, statistical analysis showed that there is a significant difference ($p<0.05$) in the heavy metals content between their pulps and peels. Similarly, the levels of Mn in the peel of paw-paw fruit significantly differ from that of pulp ($p<0.05$) and both values exceeded the permissible limits. Furthermore, levels of Mo were found to be above the permissible limits in both the pulp and peels of banana, and also in the peels of African mango. Similarly, concentrations of Pb above the permissible limits have been found in the pulp and peel of banana, and the peels of paw-paw and orange.However, the levels of other heavy metals studied in current work have been found to be

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within the tolerable limits of heavy metals content in fruits. Hence, more precautions are needed in the production, handling and consumption of some of the fruit.

Keywords: *Pollution, Heavy metals, Fruits, peel, Atomic Absorption Spectrophotometry.*

Introduction

Heavy metals are persistent and non-biodegradable, have long biological half-lives and can be bioaccumulated through the biologic chains, soil-plant-food chains, seawater-marine organism-food chains and ultimately lead to undesirable side effects (Shawi *et al.,*1999). Plants take up heavy metals by absorbing them fromairborne deposits on the parts of the plants exposed to the air from the polluted environments as well as from contaminated soils through root systems (Elbagermi *et al.,* 2012). The presence of heavy metals in the atmosphere, soil and water, even in trace amount can cause serious problems to organisms (Islam *et al.,* 2007). Their accumulation in soils is of concern in agricultural production due to the adverse effects on food quality. They are among the major contaminants of food supply and may be considered as one of the most important problems to our environment (Radwan and Salama, 2006). The uptake and bioaccumulation of metals in both fruits and vegetables are influenced by a variety of factors among which are atmospheric depositions, climate, concentrations of metals in the soil and of course, the nature of the soil in which the plant grow (Osma *et al.,* 2013). Other anthropogenic sources of heavy metals includes the addition of manures, fertilizers, sewage sludge and pesticides that uptake metals by modifying the physico-chemical properties of the soil such as pH, organic matter, redox and bioavailability of metals in the soil (Osma *et al.,* 2013). Fruits and vegetables accumulate heavy metals in their edible and non-edible parts. Thus, food safety issues and potential health risk make this as one of the most serious environmental concerns (Singh *et al.,* 2010). During the last decades, the increasing demand of food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by heavy metals, pesticides and /or toxins

(D'Mello, 2003).Based on their persistence and cumulative behaviors as well as the probability of potential toxicity effects, the absorption of heavy metals in human diets (e.g. vegetables and fruits)require the analysis of food items to ensure that the levels of heavy metals meet the agreed international standards (Elbagermi *et al.,* 2012).The increasing trends in food contamination are largely attributed to the polluted environment in agriculture, contaminated food transport and supply chains, poor market sanitary conditions, and the use of contaminated or waste water for irrigation purposes (Seyed and Somashekar, 2008).In view of the above, there is need to evaluate the heavy metals content of some of the fruit-foods consumed in this part of the world. Hence, this study is aimed at evaluating the heavy metals compositions in some selected samples of fruit consumed in Kano metropolis.

Materials and Methods

Chemical Reagents

All the chemical reagents used are of analytical grade.

Sample Collection

The fruit samples studied were African Mango (*Irvigna gabonensis*), Orange (*Citrus sinensis*), Paw-paw(*Carica papaya*), Guava(*Psidium guajava*) and Banana(*Musa spp*). All the fruit samples were purchased from Na'ibawa fruit market in the metropolitan city of Kano. The fresh samples were carefully and randomly selected, labeled properly and analyzed in the laboratory under standard laboratory procedures.

Sample Preparation and Preservation

The fresh fruit samples were initially washed in a running tap water to remove dusts, dirt and possible parasites or their eggs and then again washed with de-ionized water. The samples were dried in microwave oven (at 65^{0}C) until constant weights were obtained. The dried samples were pulverized using pestle and mortar and stored in plastic containers prior to analysis.

Sample Digestion

Five gram (5 g) each of the pulverized samples were weighed into a 50 ml beaker and 20 ml mixture of HNO_3: HCl in the ratio 1:1 were added. The digestion was performed in a fume cupboard at 190°C to a clear solution. The solution was cooled, filtered (with a Whatman filter paper) in a 50 ml volumetric flask and made up to a final volume with distilled water.

The sample heavy metals content was analyzed using Atomic Absorption Spectrophotometer (210 VGP). Measurements were made using standard hollow cathode lamps for Pb, Cd,

Zn, Cu, Co, and Ni, Fe, Mo, Cr and Mn.

Statistical analysis

The result is presented as mean $\pm$ standard deviation of triplicate readings. Student t-test at ($p<0.05$) was used to compare the significant difference between the pulp and peel of the fruit samples.

Results and Discussion

The results obtained for the heavy metals analysis in the pulps and peels of the studied samples of fruit are presented inthe table.

From the table, cadmium was only detected in banana pulp (0.42 ± 0.03 mg/kg) and peel (1.24 ± 03 mg/kg) and paw-paw peel (0.44 ± 0.06 mg/kg). The results indicate that banana peel have significantly ($p<0.05$) higher cadmium content than its pulp. The values are above the permissible limits (0.2 mg/kg) established by JECFA (FAO/WHO, 2007). A sensitive endpoint for oral exposure to cadmium is renal toxicity (Buchet *et al.,* 1990).

The table shows the concentration of cobalt in fruits. Like cadmium, cobalt was only detected in banana pulp (0.04 ± 0 mg/kg) and peel (0.18 ± 0.01 mg/kg) and paw-paw peel (0.13 ± 0.01 mg/kg). The result indicate that banana peel have significantly ($p<0.05$) higher level content than its pulp. It was observed that banana pulp has cobalt content within the permissible limit, while the concentration of cobalt in banana and pawpaw peels exceed the permissible limits of 0.1 mg/kg (EPA, 2000). Cobalt is beneficial for humans because it is part of vitamin B_{12} which is essential to maintain human health (ATSDR, 2004).

Similarly, chromium levels were only detected in African mango (pulp and peel) and guava peel (Table 1). These values are within the permissible limits of 1.5 mg/kg (FAO/WHO, 2010). Ingestion of high level of chromium has been found to target kidneys, liver and hematopoietic system (EMEA, 2007).

On the other hand, mean concentrations of copper have been detected either in the pulp or husk of all the studied fruits with the exception of orange fruit (Table). In all cases, values obtained in the peels differ significantly ($p<0.05$) from those in pulps. Copper was not detected in the pulp of pawpaw and guava. The maximum tolerable limit of copper in fruits is 40 mg/kg (FAO/WHO, 2001). Therefore, values obtained in this study are within the acceptable limits. Copper (Cu) like other metals, generally enter the contaminated environment through small scale industrial effluents (including battery production, metal products, metal melting and cable coating industries (Seyed and Somashekar, 2008). A general review of relevant safety data for animals and humans indicates that copper can produce adverse effects to the gastrointestinal tract, liver, and kidney upon ingestion of toxic doses (Araya *et al.*, 2003).

Likewise, levels of iron are found in both segments of the fruits. More so, with the exception of orange, significant difference ($p<0.05$) observed between the pulps and peels (Table). The maximum acceptable limit of iron in fruits is 56 mg/kg (FAO/WHO, 2003). Values obtained in this study are therefore within the acceptable limits of iron. Iron is an important constituent of succinate dehydrogenase as well as part of the heme of hemoglobin, myoglobin and cytochromes and also a cofactor for a number of enzymes involved in neurotransmitter synthesis (Aremu and Ibrahim, 2014). However, high levels of Fe can cause gastrointestinal symptoms (EMEA, 2007).

Manganese was detected in all the samples with the exception of orange (Table 1). Pawpaw has the highest level with its pulp having significantly ($p<0.05$) higher level. Generally the samples peels have higher level than corresponding pulp. The established maximum tolerable limit of manganese in fruits is 10.38 mg/kg (ATSDR, 2000), indicating that all the samples with the exception of pawpaw have manganese content within the acceptable limit. It has been postulated that there is a spectrum of neurobehavioural and neurophysiological effects associated with Mn toxicity, including both subclinical and clinical symptoms (Santamaria, 2008).

Mean concentrations of molybdenum in the studied fruits are presented (Table 1). Molybdenum levels were only detected in banana (pulp and peel) and African mango peel. The two fruits have their molybdenum content above the maximum tolerable limits of 0.05 mg/kg (IOM, 2001).

In the same vain, nickel was only detected in the pulp of banana as shown in the Table 1. The value is within the tolerable limit of 1.12 mg/kg established by the Nickel Producers Environmental Research Association (NiPERA, 2006). There is evidence suggesting that nickel ingestion may contribute to the exacerbation of eczema in sensitized individuals (EMEA, 2007).

The table shows the concentration of lead in the samples of fruits. Lead was detected in the peel of all samples (except guava) and pulp of banana. The maximum tolerable limit of lead in fruits is 0.3 mg/kg (WHO, 2010). This indicated that the concentrations of lead in this study are above the acceptable limits except in the peel of African mango. The high lead levels obtained in this study may be due to air-borne contamination and other industrial processes (Kalagbor *et al.*, 2014). Lead toxicity causes reduction in the haemoglobin synthesis, disturbance in the functioning of kidney, joints, reproductive and cardiovascular systems and chronic damage to the central and peripheral nervous systems (Ogwuegbu and Muhanga, 2005).

Zinc was detected in all the analyzed fruits (Table 1). No significant difference ($p>0.05$) was observed between the corresponding samples pulps and peels. The maximum tolerable limit of zinc is 60 mg/kg (FAO/WHO, 2007). Values obtained in present study are within the acceptable limits of zinc in fruits. Zinc plays an important role in several metabolic processes acting as cofactor for enzymes and involves in carbohydrate and nucleic acid metabolism (Anju *et al.*, 2011). Likewise, higher concentration of Zn can cause impairment of growth and reproduction (Nolan, 2003).

Conclusion

The results obtained in this work on the evaluation ofheavy metals in some fruits consumed in Kano metropolis were compared with the established permissible limits of heavy metals in foods/fruits. It has been observed that some of the evaluated fruits have exceeded the permissible limits while others fall within the limits. This is probably due to the differences in the uptake capability of metals by plants and further translocation to edible portions of fruits. Furthermore, methods of cultivation, transport and storage could be the possible sources of heavy metals in these fruits and of course, carbide which is widely used to induce ripening processes in fruits. Therefore, consumption of these fruits should be encouraged but observed with caution so as to avoid gradual hyper-accumulation of toxic heavy metals and potential health hazards.

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Table 1: Heavy metals content in Pulp and Peel of fruits (mg kg^{-1} dry weight)

Samples	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Zn
B_1	0.42 ± 0.03^a	0.04 ± 0^a	ND	0.16 ± 0.01^a	0.82 ± 0^a	0.86 ± 0.02	0.44 ± 0	0.43 ± 0	0.84 ± 0.02^a	0.34 ± 0.02
B_2	1.24 ± 0.03^a	0.18 ± 0.01^a	ND	0.313 ± 0^a	2.48 ± 0.02^a	0.85 ± 0.02	0.45 ± 0.02	ND	1.61 ± 0.03^a	0.34 ± 0.02
PP_1	ND	ND	ND	ND	1.91 ± 0.47^b	20.73 ± 0.49^a	ND	ND	ND	0.25 ± 0.19
PP_2	0.44 ± 0.06^b	0.13 ± 0.01^b	ND	1.55 ± 0.04^b	3.01 ± 0.47^b	17.93 ± 0.48^a	ND	ND	0.82 ± 0	0.60 ± 0.21
O_1	ND	ND	ND	ND	0.82 ± 0	ND	ND	ND	ND	0.36 ± 0
O_2	ND	ND	ND	ND	0.82 ± 0	ND	ND	ND	0.83 ± 0.02^b	0.37 ± 0.02
G_1	ND	ND	ND	ND	0.82 ± 0^c	0.84 ± 0^b	ND	ND	ND	0.36 ± 0.01
G_2	ND	ND	0.48 ± 0.01^a	1.57 ± 0.02^c	1.63 ± 0.01^c	0.56 ± 0.02^b	ND	ND	ND	0.36 ± 0
AM_1	ND	ND	0.95 ± 0.01^b	0.16 ± 0	0.62 ± 0.01^d	0.22 ± 0	ND	ND	ND	0.36 ± 0
AM_2	ND	ND	0.47 ± 0	3.13 ± 0	1.81 ± 0.01^d	0.84 ± 0	0.95 ± 0.03^a	ND	0.11 ± 0.001^c	0.36 ± 0
MLs	0.2 mg/kg[1]	0.1 mg/kg[2]	1.5 mg/kg[3]	40 mg/kg[4]	56 mg/d[5]	10.38 mg/kg[6]	0.05 mg/kg[7]	1.1 mg/kg[8]	0.3 mg/kg[9]	60 mg/kg[1]

Values are mean ± standard deviation of triplicate results. Figures followed by the same superscript in the same column are statistically significant ($p<0.05$). ND=Not Detected, B_1=Banana Pulp, B_2=Banana Peel, PP_1=Pawpaw Pulp, PP_2=Pawpaw Peel, O_1=Orange Pulp, O_2=Orange Peel, G_1=Guava Pulp, G_2=Guava Peel, AM_1=African mango Pulp, AM_2=African mango Peel. MLs= Maximum Limits, Superscript 1= FAO/WHO, (2007), 2= (EPA, 2000), 3= FAO/WHO (2010), 4= FAO/WHO, (2001), 5= FAO/WHO JECFA, (2003), 6= ATSDR, (2000), 7= (IOM, 2001), 8= EPA, (2001), 9= (WHO, 2010)